Environ Monit Assess
DOI 10.1007/s10661-008-0263-0

Assessing an exotic plant surveying program in the Mojave Desert, Clark County, Nevada, USA

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Received: 27 August 2007 / Accepted: 29 February 2008
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Abstract Exotic species can threaten native ecosystems and reduce services that ecosystems provide to humans. Early detection of incipient populations of exotic species is a key step in containing exotics before explosive population growth and corresponding impacts occur. We report the results of the first three years of an exotic plant early detection and treatment program conducted along more than 3,000 km of transportation corridors within an area >1.5 million ha in the Mojave Desert, USA. Incipient populations of 43 exotic plant species were mapped using global positioning and geographic information systems. *Brassica tournefortii* (Sahara mustard) infested the most soil types (47% of 256) surveyed in the study area, while *Nicotiana glauca* (tree tobacco) and others currently occupy less than 5% of soil types. *Malcolmia africana* (African mustard) was disproportionately detected on gypsum soils, occurring on 59% of gypsum soil types compared to 27% of all surveyed soils. Gypsum soils constitute unique rare plant habitat in this region, and by conventional wisdom were not previously considered prone to invasion. While this program has provided an initial assessment of the landscape-scale distribution of exotic species along transportation corridors, evaluations of both the survey methods and the effectiveness of treating incipient populations are needed. An exotic plant information system most useful to resource mangers will likely include integrating planning oriented coarse-scale surveys, more detailed monitoring of targeted locations, and research on species life histories, community invasibility, and treatment effectiveness.

Keywords Distribution · Invasibility · Landscape · Mapping · Monitoring · Roads · Transportation corridor

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Introduction

Exotic species in general are threats to native ecosystems and to ecosystem services provided to human societies (Higgins et al. 1999; DiTomaso 2000). For example, *Tamarix ramosissima* (saltcedar) invasion of riparian areas in the western United States often depresses plant diversity (Busch and Smith 1995). Dense stands of this deep-rooted exotic tree with high leaf area also can usurp more water than native riparian vegetation of lower leaf area, reducing available water for native wildlife and for human populations in the arid West (Shafroth et al. 2005).

Estimated economic impacts of exotic *Tamarix* species to agriculture and other resource values in the western United States range from \$133–285 million (1998 US dollars) annually (Zavaleta 2000). Another example is the establishment of exotic annual grasses (e.g., *Bromus rubens* [red brome]) in western deserts, which has fueled wildfires not thought to have been prevalent before invasion (D'Antonio and Vitousek 1992). These wildfires kill long-lived native plants such as *Yucca brevifolia* (Joshua tree), increase soil erosion, reduce air quality, threaten or burn human habitations, and may cost millions of dollars to attempt to suppress (Brooks and Pyke 2001).

As opposed to attempted eradication of established populations, preventing undesired exotic species from arriving to an area in the first place is considered the most economical and ecologically viable means for limiting exotic species impacts (Moody and Mack 1988; Davies and Sheley 2007). Prevention is not currently completely feasible, however, because expanding human populations in the arid West increase dispersal vectors and disturbance, combined with "natural" dispersal mechanisms such as water, wind, or animals (Rejmánek 1996). Furthermore, the meta-analysis of Levine et al. (2004) found little evidence that any native ecosystem can completely repel invasion given intense propagule pressure from potential invaders. Failing prevention, the next most cost effective and feasible strategy is the early detection and treatment of exotic species populations when they are still small (Davies and Sheley 2007). Exotic species frequently exhibit a lag time between introduction and the occurrence of explosive population growth and corresponding impacts (Hobbs and Humphries 1995). However, treating exotic species populations during this lag time requires that the species are first detected and mapped (Dewey and Andersen 2004; Underwood et al. 2004; Barnett et al. 2007).

We document an early detection system, known locally as the "Weed Sentry" program, operating in Clark County, Nevada, USA, in the Mojave Desert. This program presupposes that knowing the exotic species present in an area and their distribution is a key step for forestalling widespread infestations and for developing a long-term exotic species management plan. This program recognizes that not all potential exotic invaders will have large impacts, not all invaders may be able to be stopped, and more research ideally would be available on invasion ecology in this region. Nevertheless, this program assumes that "doing nothing" or waiting for more research violates precautionary principles (Underwood 1997). Thus, this program detects and facilitates the eradication of small, incipient exotic plant populations to attempt, in accordance with precautionary principles, to preclude additional widespread infestations. The Weed Sentry program is implemented by the University of Nevada Las Vegas through a cooperative agreement with the US National Park Service, and operates on an interagency basis on federal lands in southern Nevada managed by the National Park Service, Bureau of Land Management, Fish and Wildlife Service, and the Forest Service. We report the first 3 years of exotic species survey data collected by this program, assess methods and assumptions of the program, and suggest future work for advancing exotic species information systems in this region.

Materials and methods

Study area

Clark County, Nevada, is in the eastern Mojave Desert and encompasses a wide elevational range from 137 m near the Colorado River to 3,634 m in the Spring Mountains (Lato 2006; Fig. 1). Precipitation varies sharply from year to year, with a long-term (1937–2006) average of 11 cm/year at a 662 m elevation in the city of Las Vegas in central Clark County (Western Regional Climate Center, Reno, Nevada, USA). High temperatures average 14°C in January and 41°C in July. At a shorter term (2005–2006) weather station in the county at a higher elevation of 2,195 m in Kyle Canyon of the Spring Mountains, annual precipitation ranged from 35–60 cm, average January high temperatures from 7.6–8.3°C, and average July high temperatures from 29–30°C (Doug Merkler, US Natural Resources Conservation Service, *unpublished data*). Predominant plant communities from low to high elevation include *Larrea tridentata* (creosote bush) desert scrub, *Coleogyne ramosissima* (blackbrush) shrubland, *Pinus*-*Juniperus* (pinyon-juniper) woodland, and higher elevation *Pinus ponderosa* (ponderosa pine) or mixed conifer forest (Rowlands et al. 1982). Clark County contains more than 1.5 million ha of federal land, including Lake Mead National Recreation Area (National Park Service), Desert National Wildlife

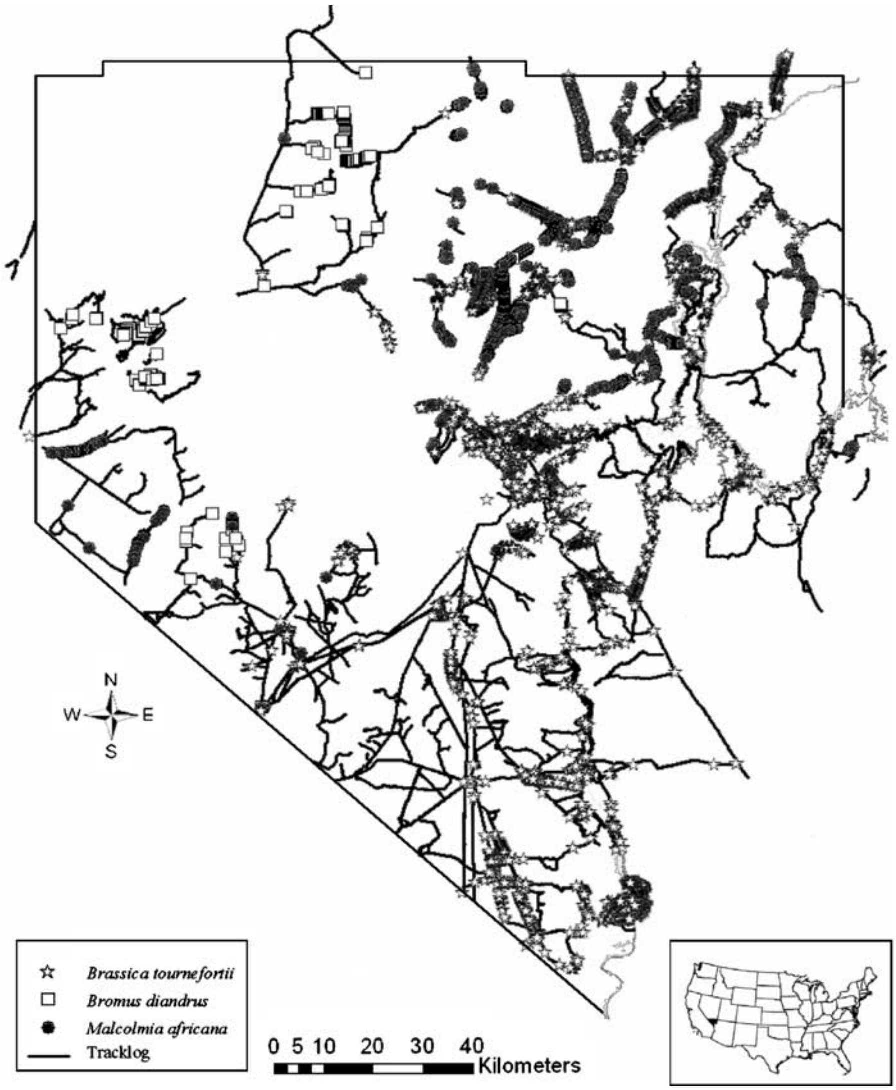

Fig. 1 Map of Clark County, Nevada, USA, showing roads and trails surveyed and distributions of three exotic species as examples of low- (*B. tournefortii*, *M. africana*) and high-elevation species (*B. diandrus*) of 43 total surveyed species

Refuge (Fish and Wildlife Service), Spring Mountains National Recreation Area of the Humboldt-Toiyabe National Forest (Forest Service), and Bureau of Land Management holdings. Human visitation is intense on some of these federal lands. For example, an average of nine million people visited Lake Mead National Recreation Area annually between 1995–2006 (Inside National Park Service, Washington, D.C., USA). Las Vegas, the largest metropolitan area in Clark County, experienced an 83% population growth from 1990–2000, which was the most rapid growth of any US metropolitan area during that time period (Perry and Mackun 2001). By 2006, Las Vegas contained an estimated 1.8 million people (Southern Nevada Regional Planning Coalition 2006).

Field procedures

More than 3,000 km of roadsides, trails, and shorelines (Lakes Mead and Mohave, formed when the Colorado River was impounded) were surveyed by vehicle, on foot, or by boat in a 35-month period from 2003–2006 (Table 1, Fig. 1). Roads, trails, and shorelines were chosen as survey areas because it was believed these areas would serve as establishment points and dispersal corridors (Tyser and Worley 1992; Gelbard and Belnap 2003; Hansen and Clevenger 2005). Survey routes and exotic plant species were recorded using a Global Positioning System (GPS) tracklog in 0.16 km (0.1 miles) increments along roadsides and in approximately the same

Table 1 Characteristics of exotic plant surveys along roadways, trails, and lake shorelines in Clark County, Nevada, USA, from November 2003 to September 2006

Measure	Value
Total survey distance (km)	3,325
No. soil types surveyed[a]	256
Min. elevation (m)	137
Max. elevation (m)	3,634
No. exotic species surveyed/detected[b]	43
Annual precipitation (% of mean)[c]	
2002	34
2003	161
2004	182
2005	173
2006	42

[a] No. of soil classification units, including soils classified as badlands, surveyed within 2 soil survey areas (Bagley 1980; Lato 2006)

[b] Species were based on those chosen *a priori* to survey for, and new species detected during surveys

[c] Percent of the 67-year mean (1937–2006) measured at the city of Las Vegas airport (Western Regional Climate Center, Reno, Nevada, USA)

increments along irregularly shaped shorelines or trails. Thus, this systematic approach to surveying recorded both species presence and absence, which permits distinguishing between unsurveyed area and true absences at the time of surveying (Barnett et al. 2007). In road surveys by vehicle, both sides of the road were surveyed up to 10 m away from the road edge. Similar to road surveys, approximately 10 m of shoreline inland from the water's edge were surveyed by boat in shoreline surveys. This distance was chosen for practical reasons as approximately the greatest distance that surveyors could see and identify plant species, as was also determined by Shuster et al. (2005). Driving speeds during roadside and boat surveys were approximately 5–15 km/h. The approximate number of plants of each species in each 0.16 km increment was coarsely categorized as <10, 10–100, 101–1,000, and >1,000 individuals. Unknown plant specimens were collected, pressed, and identified by a botanist. Surveying 1.6 km (1 mile) by vehicle or boat required approximately 10–20 min on average for a crew of one to two people. To correspond to periods of active growth for most species, surveys were conducted in fall, winter, and spring in lower elevation desert areas and in spring and summer in higher elevation forests. However, the presence of dead annual species also was recorded for enhancing species detection in dry years or if the period of active growth was missed by surveys.

Upon discovering an exotic species occurrence, crews chose whether to treat the plants at that time using herbicide or hand pulling. Small incipient populations and populations in remote areas were most frequently treated upon discovery, consistent with the early detection and treatment objectives of the program. Trip reports providing maps of species occurrences and numbers of plants treated or suggestions for future treatment were provided to land management agencies during ongoing survey efforts.

A priori species targeted to look for during surveys were those suggested by federal land managers in Clark County, state noxious weed lists (Nevada, and the neighboring states of Arizona, California, Utah, and New Mexico), and weed lists from the five counties adjacent to Clark County. New species were added to the survey list as they were detected during surveys. Some exotic species known to occur in Clark County were not surveyed for because they are ubiquitous in much of the county (e.g., *B. rubens*, *Schismus* spp. [Mediterranean grass]), and, therefore, were not considered relevant to the early detection focus of the program. Other species (e.g., *Erodium cicutarium* [filaree]) that were not thought to have high invasive or impact characteristics also were not surveyed. Nomenclature and classification of species by lifeform and as native/exotic follow USDA NRCS (2007).

Data analysis

Data were downloaded from GPS units into a database and viewed using a Geographic Information System. To evaluate species distributions among soil types, we obtained digital data from soil surveys of Clark County (Bagley 1980; Lato 2006). These surveys typically classified soils to the association (Lato 2006) or series levels (Bagley 1980). We totaled the number of kilometers of roadsides, trails, or shorelines on which exotic species were detected in each soil taxonomic unit and computed the average number of species occurrences per kilometer in each soil type. Soils classified as "badlands" were included. Lato (2006) defined badland soils as non-stony soils of soft geologic material dissected by many intermittent drainages. We descriptively assessed relationships between species occurrences and soil types, elevation, and the presence or absence of gypsum (defined as soils containing >5% gypsum in the upper 15 cm of soil according to the published soil surveys). To evaluate which soil types may be most infested, we calculated the mean number of species occurrences per kilometer surveyed for each soil type.

Results and discussion

Survey coverage and conditions

Surveys along more than 3,000 km of transportation corridors crossed more than 250 soil types (Table 1). Survey coverage was extensive, with most backcountry roads (dirt and gravel surface) in Clark County being surveyed at least one or two of the three survey years (Fig. 1). Freeways and other high-speed roadways, however, were not surveyed due to safety concerns about a need to travel sufficiently slow to identify species. Annual precipitation during a 5-year period encompassing the survey period varied nearly six-fold from 34% to 182% of the long-term average (Table 1). This high inter-annual variation, typical of the Mojave Desert (Rowlands et al. 1982), can have a major effect on plant recruitment, particularly for annual plants where germination and abundance are closely linked to precipitation (Beatley 1974).

Species distribution and frequency

Occurrences of several of the 15 most frequently encountered species (of 43 total survey species; Appendix) were related to elevation (Table 2). For example, the only detected occurrences of *Nicotiana glauca* (tree tobacco) and *Lepidium latifolium* (tall white top) were below 915 m, while *Sisymbrium altissimum* (tumblemustard), *Bromus diandrus* (ripgut brome), and *Descurainia sophia* (herb sophia) exhibited their most occurrences/km at elevations above 1,830 m. Other species, such as *Hordeum vulgare* (common barley), *Sisymbrium orientale* (Indian hedgemustard), and *Bromus tectorum* (cheatgrass) occurred across a broader range of elevations. With an average of 1.3–1.6 occurrences/km, *Brassica tournefortii* (Sahara mustard) was the most frequently detected species below 915 m elevation. It is important to note that the nearly ubiquitous *B. rubens* and *Schismus* spp. were not surveyed and thus are not included in species frequency rankings.

Table 2 Summary of elevational distributions of the 15 most frequently encountered exotic species (of 43 total species) during roadside, trail, and shoreline surveys, Clark County, Nevada, USA, from November 2003 to September 2006

Species	Elevation class (m)				
	<610	610–915	915–1,220	1,220–1,830	>1,830
			Mean occurrences/km		
Nicotiana glauca	**0.2**	<0.1	0	0	0
Lepidium latifolium	**<0.1**	**<0.1**	0	0	0
Nerium oleander	**<0.1**	**<0.1**	0	0	0
Tamarix ramosissima	**0.2**	<0.1	<0.1	<0.1	0
Malcolmia africana	**0.3**	**0.5**	<0.1	<0.1	0
Brassica tournefortii	**1.6**	**1.3**	0.2	<0.1	0
Hordeum murinum	**<0.1**	**<0.1**	0	**<0.1**	0
Hordeum vulgare	<0.1	**0.1**	<0.1	<0.1	<0.1
Sisymbrium irio	<0.1	**0.2**	**0.2**	<0.1	0
Sisymbrium orientale	<0.1	<0.1	**0.1**	<0.1	<0.1
Bromus tectorum	0.2	0.9	0.6	**1.1**	**1.0**
Bromus berteroanus	<0.1	**0.1**	<0.1	**0.1**	0
Sisymbrium altissimum	<0.1	<0.1	<0.1	**0.2**	**0.3**
Bromus diandrus	<0.1	<0.1	<0.1	<0.1	**0.2**
Descurainia sophia	0	<0.1	<0.1	**0.2**	**0.3**

Species are arranged in order of increasing frequency with increasing elevation, with values in bold highlighting the greatest frequencies of species

Soil relationships

Few relationships between soil types and exotic species distributions were evident. For example, *B. tournefortii* occurred on 91% (41/45) of soil types in the <610 m elevation belt for soil types where ≥1 km were surveyed. Occurrences per kilometer showed no trend to vary predictably among soil types. The major soil survey in Clark County (Lato 2006) is an order 3 survey, which is relatively coarse, so it may not capture environmental heterogeneity of specific exotic species establishment points. Differences in exotic species establishment can occur on microscales in the Mojave Desert, such as between openings and below shrubs only a few meters apart (Brooks 1999). Soils could be related to exotic distributions if soils serve as an "environmental filter" regulating where species can establish based on species tolerances or dispersal, or if disturbance is correlated with soil types (DeFarrari and Naiman 1994; Stohlgren et al. 1999). However, establishing species–soil relationships would be difficult for most species in our data set, as 58% (25/43) of surveyed species occurred in 2% or fewer (≤5/256) soil types. We cannot distinguish whether these species are incapable of growing on other soil types or if propagules have simply not arrived on other soil types.

Malcolmia africana (African mustard) was an exception to the trend of species in our data set showing little relationship to the coarse-scale soil survey. This annual forb occurred on more than twice as many gypsum soil types than expected based on its distribution among all soil types (Fig. 2). *M. africana* is not restricted to gypsum soils, as we recorded it in 50 non-gypsum soil types, consistent with Van Buren and Harper (2003) who recorded the species on limestone and other soils containing <1% gypsum in southwestern Utah. Since many of *M. africana*'s occurrences were near the border of southwestern Utah in northeastern Clark County (Fig. 1), where gypsum soils also are concentrated, it cannot be ruled out that this species' distribution is correlated with the geographic proximity to other populations that may have expanded. Regardless, *M. africana*'s preponderance on gypsum soils could be a concern because these soils harbor several low-elevation rare plant species such as *Arctomecon californica* (Las Vegas bearpoppy; Meyer 1986). Conventional wisdom in this region also did not consider gypsum soils to be prone to invasion.

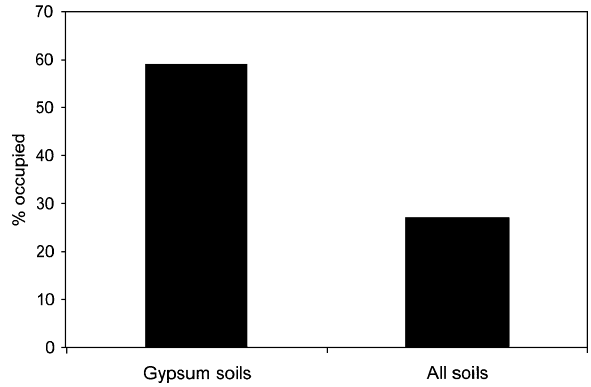

Fig. 2 *M. africana* occurred on 12/21 gypsum soil types in Clark County, Nevada, more than twice as many as expected by chance

Survey and treatment effectiveness

In evaluating the assumptions and effectiveness of this program, it is important to keep in mind that waiting to take action before thorough and long-term research or monitoring of exotic species in this region are well underway would defeat the program's goal of providing early detection and treatment of incipient populations. Furthermore, the program was targeted to be adaptive based on the first few years of survey data and can be viewed as a tool for helping to guide research priorities. Both this program's survey methods and the effectiveness of early detection and removal of incipient populations require evaluation.

A major assumption of the survey methods is that roads, trails, and shorelines are vectors of exotic species dispersal and establishment. This program concentrated surveys along these corridors, assuming that eradicating incipient populations in these areas forestalls invasion of other corridors and interior areas. Previous studies in southwestern arid lands have found that exotic plants overall are more abundant along roadsides than in interior areas (e.g., Gelbard and Belnap 2003). However, even small populations that establish in interior areas could form nascent foci that expand to infest additional interior area that would be out of view of roadside surveys (Cowie and Werner 1993). Surveying interior areas when an incipient population is found along a roadway, together with surveying other interior areas, may increase the generality of surveys (Shuster et al. 2005; Barnett et al. 2007).

Observations about the effectiveness of this program's early detection and treatment system suggest some encouraging outcomes. For example, this program treated a total of 37,744 exotic plants in incipient populations in a 12-month period between October 2005 and September 2006. These plants were from a total of 26 exotic species on National Park Service, Bureau of Land Management, Forest Service, and Fish and Wildlife Service land throughout Clark County. As one example, new individuals of *N. glauca* have been sprayed with herbicide annually from 2003–2005 in Monkey Cove above the shoreline of Lake Mead. Observations in 2006 did not reveal any new individuals, although continued monitoring is needed in a moister year (Table 1). In another example, a population of 272 individuals of *Peganum harmala* (African rue) was detected and treated in 2006 using hand pulling and herbicide. In 2007 only ten *P. harmala* individuals occurred at this site, which will be re-treated. No other infestations of this species have since been detected in the survey area. Particularly for more widespread invaders, quantitative monitoring ideally could be performed where some populations are treated and some are not in order to isolate treatment effectiveness. Ethically, however, it is difficult to justify not treating all located incipient populations of an exotic species with potential for damaging native ecosystems. Nevertheless, if the exotic plant is not present on or off-site for several years (including wet and dry years) after treatment, the outcome is successful following precautionary principles (Underwood 1997), whether or not the outcome can be directly attributed to the treatment.

Recommendations

In our view, some changes or additions to this program in species selection for surveying, survey methods, and assessments of exotic species ecology could be considered to advance this exotic species information system. *B. rubens* and *Schismus* spp. are considered among the most widespread and high-impact (by changing disturbance regimes from infrequent to frequent fire) exotic plants in the Mojave Desert (Brooks and Pyke 2001). However, these species were not surveyed because the program focused on detecting new invaders before they are firmly established. The abundance of these exotic annual grasses, however, may vary substantially across the landscape (Beatley 1966). Recording a rapid, coarse measure of abundance (e.g., cover estimation) of these species as part of this program's surveying may help resource managers plan for potential fire hazards and identify high-impact areas (Link et al. 2006).

The assumption of restricting surveys to transportation corridors could be evaluated to ensure that incipient populations were not missed in interior areas. In particular, washes, animal trails, or other features in interior areas may also serve as vectors (Rejmánek 1996) and could be surveyed. As Dewey and Andersen (2004) note, surveys and repeated monitoring provide complementary, but different, information for exotic species management. A network of permanent monitoring plots could be established at strategic locations and sampled periodically to provide more detailed quantitative information on exotic species abundance than can be provided by coarse surveys (Barnett et al. 2007). These plots may be particularly appropriate in areas where incipient populations have been treated.

Given limited budgets, consideration also could be given to how frequently surveys need to be conducted; currently they are conducted annually. Mojave Desert vegetation, particularly annuals, is closely linked to precipitation and may not be readily visible in dry years (Beatley 1974). Exotic annuals that do germinate in dry years also tend to be smaller in size, and thus may be more difficult to spot during vehicle and boat surveys. Concentrating surveying to wet years may provide the most comprehensive distributional data and represent the most efficient use of resources. On the other hand, the relative benefits of treating species in wet versus dry years is not known. It is possible that treating species in refugium areas (e.g., moist microsites) in dry years may sharply reduce populations. Furthermore, runoff is concentrated along roadsides, which may allow species to persist during dry years (Johnson et al. 1975).

Little published literature or practical knowledge exists about many of the new invaders surveyed (Kemp and Brooks 1998; Bossard et al. 2000), making it difficult to prioritize and plan containment treatments and develop monitoring programs. Information about seed bank formation, seed dispersal, and propagule pressure (Von Holle and Simberloff 2005) would be particularly valuable for many species, as well as information on the effectiveness of hand pulling, herbicide application, or other treatments in a range of potential management situations. In addition, clarifying factors regulating community invasibility requires further work not only in the Mojave Desert, but also in the field of invasion ecology in general (Byers et al. 2002).

This program has produced a map showing species invasion along transportation corridors across a broad landscape (Fig. 1). We believe that periodically resurveying to continue to update exotic species distributions is one of the best known approaches this region has for curtailing widespread infestations by new invaders. Now that a map exists of these species, however, surveying tells little about what to do about current and future incipient populations and larger infestations. A successful exotic plant information system will likely need to go beyond surveying alone, to also incorporate effectiveness monitoring, generate new or synthesize existing published research on invasibility and treatments, and be adaptive to new invaders or to changes in ecosystem invasibility.

Acknowledgements Funding for the Weed Sentry program was provided by the Clark County Multiple Species Habitat Conservation Plan through the Southern Nevada Public Land Management Act and by the National Park Service (Lake Mead National Recreation Area). Funding for the preparation of this manuscript was awarded by the National Park Service through a cooperative agreement, facilitated by Angie Evenden (Research Coordinator, National Park Service). Elizabeth Powell provided insight and direction in early phases of the program; Stacey Provencal (Bureau of Reclamation) developed and maintained the data collection and storage system; Kashmira Asnani, Tiffany Finke, James Fitzgerald, and Jennifer Frey helped collect survey data; Dianne Bangle (University of Nevada Las Vegas) identified plant specimens; Joe Hutcheson (Lake Mead National Recreation Area) guided GIS analyses of soil–species relationships; and Doug Merkler (Natural Resources Conservation Service), Alice Newton (Lake Mead National Recreation Area), and Cayenne Engel and Jill Craig (University of Nevada Las Vegas) provided helpful comments on earlier drafts of the manuscript.

Appendix

List of 43 exotic plant species surveyed by the Weed Sentry program, Clark County, southern Nevada, USA

Species	Family	Lifeform	% soils occupied[a]
Annuals			
Avena fatua	Poaceae	Grass	0.8
Brassica tournefortii	Brassicaceae	Forb	46.9
Bromus berteroanus	Poaceae	Grass	9.8
Bromus tectorum	Poaceae	Grass	44.9
Chorispora tenella	Brassicaceae	Forb	2.0
Halogeton glomeratus	Chenopodiaceae	Forb	1.6
Hordeum marinum	Poaceae	Grass	0.4
Hordeum murinum	Poaceae	Grass	7.0
Hordeum vulgare	Poaceae	Grass	7.8
Malcolmia africana	Brassicaceae	Forb	27.3
Poa annua	Poaceae	Grass	0.4
Polypogon monspeliensis	Poaceae	Grass	0.8
Ranunculus testiculatus	Ranunculaceae	Forb	1.2
Salsola tragus	Chenopodiaceae	Forb	1.6
Sisymbrium irio	Brassicaceae	Forb	31.6
Sisymbrium orientale	Brassicaceae	Forb	19.5
Tribulus terrestris	Zygophyllaceae	Forb	0.4
Triticum aestivum	Poaceae	Grass	1.2
Biennials, annual-perennials			
Bromus diandrus	Poaceae	Grass	6.6
Centaurea melitensis	Asteraceae	Forb	1.2
Descurainia sophia	Brassicaceae	Forb	8.2
Melilotus officinalis	Fabaceae	Forb	2.7
Sisymbrium altissimum	Brassicaceae	Forb	12.1
Tragopogon dubius	Asteraceae	Forb	1.2
Verbascum thapsus	Scrophulariaceae	Forb	3.5
Perennials			
Acroptilon repens	Asteraceae	Forb	2.3
Agropyron cristatum	Poaceae	Grass	2.3
Alhagi pseudalhagi	Fabaceae	Shrub	0.8
Arundo donax	Poaceae	Shrub/grass	0.8
Convolvulus arvensis	Convolvulaceae	Forb	0.4
Elaeagnus angustifolia	Elaeagnaceae	Shrub	0.4
Lepidium latifolium	Brassicaceae	Forb	4.3
Marrubium vulgare	Lamiaceae	Forb	5.5
Nerium oleander	Apocynaceae	Shrub	2.0
Nicotiana glauca	Solanaceae	Shrub	3.1
Peganum harmala	Zygophyllaceae	Forb	0.4
Pennisetum setaceum	Poaceae	Grass	3.5
Phoenix dactylifera	Arecaceae	Tree	0.8
Sorghum halepense	Poaceae	Grass	0.4
Tamarix aphylla	Tamaricaceae	Tree/shrub	6.6
Tamarix ramosissima	Tamaricaceae	Tree/shrub	20.7
Taraxacum officinale	Asteraceae	Forb	3.9
Ulmus pumila	Ulmaceae	Shrub	0.4

[a] Percent of the total number (256) of surveyed soil classification units in which a species was recorded at least once. Soil classification data were obtained from Lato (2006) and Bagley (1980)

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